DOCUMENTING CHEMICAL ASSIMILATION IN A BASALTIC LAVA FLOW. K. E. Young[1], J. E. Bleacher[2], D. H. Needham[3], C. Evans[4], P. L. Whelley[5], S. Scheidt[6], D. Williams[7], A. D. Rogers[8], and T. Glotch[8], [1]University of Texas, El Paso/Jacobs JETS Contract at NASA Johnson Space Center, Houston, TX, 77058 (kelsey.e.young@nasa.gov); [1]University of Texas, El Paso/Jacobs JETS Contract at NASA Johnson Space Center, Houston, TX, 77058; [2]NASA Goddard Space Flight Center, Greenbelt, MD, 20771; [3]NASA Marshall Space Flight Center, Huntsville, AL, 35812; [4]NASA Johnson Space Center, Houston, TX, 77058; [5]USRA at NASA Goddard Space Flight Center, Greenbelt, MD, 20771; [6]University of Arizona, Tucson, AZ, 85721; [7]Arizona State University, Tempe, AZ, 85281; [8]Stony Brook University, Stony Brook, NY, 11794

Introduction: Lava channels are features seen throughout the inner Solar System, including on Earth, the Moon, and Mars. Flow emplacement is therefore a crucial process in the shaping of planetary surfaces. Many studies have investigated the dynamics of lava flow emplacement, both on Earth and on the Moon [1,2,3] but none have focused on how the compositional and structural characteristics of the substrate over which a flow was emplaced influenced its final flow morphology.

Within the length of one flow, it is common for flows to change in morphology, a quality linked to lava rheology (a function of multiple factors including viscosity, temperature, composition, etc.). The relationship between rheology and temperature has been well-studied [4,5,6] but less is understood about the relationship between a pre-flow terrain's chemistry and how the interaction between this flow and the new flow might affect lava rheology and therefore emplacement dynamics.

Lava erosion. Through visual observations of active terrestrial flows, lava erosion has been well-documented [i.e. 7,8,9,10]. Lava erosion is the process by which flow composition is altered as the active lava melts and assimilates the pre-flow terrain over which it moves. Though this process has been observed, there is only one instance of where it was been geochemically documented.

Ape Cave Chemical Assimilation Study: The one case where chemical assimilation was documented was in the Cave Basalt lava tube system near Mout St. Helens, WA, in Ape Cave [11]. In this study, Williams et al. collected samples from several locations throughout Ape Cave lava tube. Field evidence (Fig. 1) shows evidence of chemical assimilation in pre-flow sediments in the wall of Ape Cave and chemical analyses document that erosion occurred in areas near the vent and in steeper sections of the tube. These laboratory analysis demonstrate that it is possible to document chemical assimilation in volcanic systems. However, this assimilation process has not yet been documented in open surface channels in terrains and flow-types like what are seen on other planetary surfaces. This study documents the first example of chemical assimilation in a terrestrial surface basaltic flow, the lunar and martian analog December 1974 flow at Kilauea Volcano, HI.

Figure 1: The Ape Cave lava tube, as shown in Williams et al., 2004. "1" represents the pre-flow sediments fused by the heat of the forming tube; "2" and "3" show the wall of the Ape Cave lava tube that indicate thermal erosion has occurred in the tube. This study looks for similar signatures at the December 1974 flow, HI.

December 1974 Flow: The December 1974 (D1974) lava flow is located in the southwest rift zone at Kilauea Volcano, HI. The 13-km long flow was emplaced from a series of en echelon fissures over a course of ~6.5 hours as a sheet flow over a series of older lava flows, active fumarolic vents, ash units, and basaltic aeolian and fluvial deposits [12,13,14,15,16]. The D1974 flow has been identified as a planetary analog due to the ongoing interaction between the flow and the sulfuric gases coming from the active Kilauea plume, the presence of overlapping basaltic flows, ash, and sediment, and the low-slope morphology of the flow over the pre-existing terrain.

We chose the D1974 flow for this study both for its qualities as a robust planetary analog site as well as for its relationship to the flow beneath it. The D1974 flow was emplaced in and around the hummocky surface of an older flow. As the D1974 flow was not thick enough to complete inundate this hummocky terrain, it flowed around tumuli of the older flow, forming "islands" [17].

RIS⁴E at the D1974 flow: The RIS⁴E SSERVI (Remote, In Situ and Synchrotron Studies for Science and Exploration; Solar System Exploration Research Virtual Institute) team and previously-funded PG&G projects have been conducting fieldwork at the D1974 flow for the last several years. RIS⁴E team goals are to investigate the emplacement, mineralogy, and geochemistry of the analog and to develop an exploration strategy for similar environments using field portable instruments. Field technologies tested include x-ray diffraction (XRD), handheld x-ray fluorescence (hXRF), multispectral imaging, light detection and ranging (LiDAR), and airborne imaging using a kite-mounted camera system. Figure 2 shows an image taken with this kite-based platform of a tumulus of the older flow showing through the younger D1974 flow.

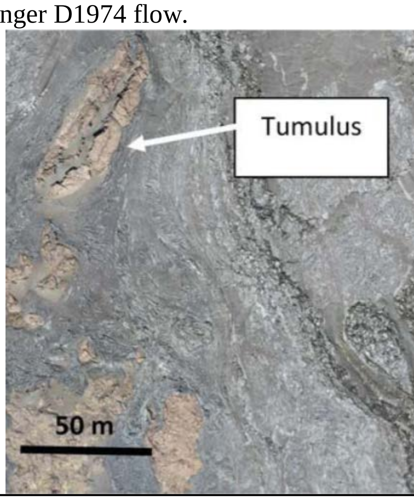

Figure 2: Image taken from the kite-based camera platform showing the younger, darker D1974 flow inundating the older, redder flow. Sites like this were sampled to investigate if there was any chemical assimilation taking place between the two flows.

Chemical Assimilation at the D1974 Flow: In order to determine if any chemical assimilation occurred between the D1974 flow and the older flow, we sampled a tumulus (Figure 3) where the D1974 flow is in direct contact of an island of the older flow. Several hXRF analyses were performed at the feature shown in Figure 3. The measurement strategy involved analyzing basalt from the older flow ~1m from the D1974 flow, at the contact between the flows, and in the D1974 flow itself. Table 1 show data from four key elements, which we interpret as evidence that chemical assimilation has occurred between the two flows. These data show both that it is probable that the chemical interactions between the two flows occurred and that it is possible to detect this relationship with field portable technology.

Figure 3: Field photo of an analyzed tumulus at the D1974 flow. In situ hXRF measurements were taken from the D1974 flow across the contact into the older flow. **Table 1:** In situ hXRF measurements show assimilation between the younger D1974 flow and the older, redder flow for four key elements.

Oxide (results show in wt. %)	D1974 Bulk	Older Flow at Contact	Old Flow Inches from Contact	Old Flow Bulk
MgO	22.54	22.46	19.15	16.05
SiO2	39.02	41.22	48.17	58.24
CaO	7.31	6.31	5.67	3.61
Fe2O3	17.49	14.76	12.88	12.11

Moving Forward: After the initial observations of chemical assimilation at the D1974 flow, it is clear that observing this process in situ is possible. More work is needed to characterize the extent of chemical assimilation across the entire D1974 flow to unravel what role this process may play in how a flow is emplaced. Additionally, modeling chemical assimilation both on Earth and for lunar flows could tell us more about how the interaction between a new flow and surrounding terrain could impact flow emplacement.

References: [1] Hulme, 1982. [2] Williams et al., 2000. [3] Hurwitz et al., 2012. [4] Keszthelyi, 1995. [5] Harris et al., 1998. [6] Harris and Rowland, 2001. [7] Greeley, 1971. [8] Wood, 1981. [9] Dawson et al., 1990. [10] Kauahikaua et al., 1998. [11] Williams et al., 2004. [12] Decker and Christiansen, 1984. [13] McPhie et al., 1990. [14] Lockwood et al., 1999. [15] Craddock et al., 2012. [16] Dietterich and Cashman, 2014. [17] Bleacher et al., 2015.